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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAMME

FOR THE

BERKELEY MEETING

AT

THE UNIVERSITY OF CALIFORNIA

BERKELEY, CALIFORNIA

JULY 11, 1942

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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

BERKELEY MEETING, JULY 11, 1942

THE 250th meeting of the American Physical Society will be held in LeConte Hall at the University of California, Berkeley, California, on July 11, 1942.

Sessions for the presentation of ten-minute contributions will be held in Room 212 at 9:30 A.M. and at 1:30 P.M. Members and others in attendance will be enabled to take luncheon together.

GENERAL RULES RELATING TO PAPERS

No paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for that meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of the abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review*.

Subsequent meetings of the Physical Society are scheduled as follows:

251. Chicago, November 27–28, 1942.
252. New York, December 28–31, 1942.

R. T. BIRGE,
Local Secretary for the Pacific Coast,
University of California,
Berkeley, California.

June 29, 1942.

JUN 30 1942

PROGRAMME

SATURDAY MORNING AT 9:30 O'CLOCK

Room 212

1. Some Isotope Shifts in the Atomic Spectrum of Nitrogen. J. R. HOLMES, *University of California. (Introduced by F. A. Jenkins.)*—The line spectrum of a mixture of N^{15} and N^{14} kindly furnished by Professor H. C. Urey was photographed with a Fabry-Perot interferometer. A liquid-air cooled quartz tube with external electrodes excited by a 12-meter oscillator was used as a source. The tube was charged with helium at a few mm pressure containing about 0.03 mm of a mixture of the nitrogen isotopes. The lines from this discharge were so sharp that it was possible to resolve completely the two components due to N^{14} and N^{15} in nine infra-red lines. No nitrogen lines were found in this discharge in the visible and ultraviolet. The oscillator excitation produced a remarkably high intensity in the lines found. The lines of $^4P \rightarrow {}^4P$ and $^4S \rightarrow {}^4P$ transitions showed a negative isotope shift of the order of 0.06 cm^{-1}. $^2P \rightarrow {}^2P$ transitions showed a positive shift of the order of 0.07 cm^{-1}. The variations in the isotope shifts within the $^2P \rightarrow {}^2P$ multiplets indicate some deviation from Russell-Saunders coupling. No hyperfine structure in either component was observed in any of the lines. The directions of the shifts were checked by obtaining the abundance ratio of the isotopes in the discharge from the intensities of the isotopic heads in the second positive N_2 bands.

2. The Criterion for Streamer Formation. GERHARD L. WEISSLER AND LEONARD B. LOEB. *University of California.*—Meek's criterion for streamer formation is that the positive space charge tip field of an electron avalanche exceed $1 > K > 0.1$ times the impressed field. Evaluation of K is influenced by electron diffusion. Estimates of K had come from uncertain values of sparking potentials. A careful study of streamer onset in confocal paraboloid gaps in moist and dry air and H_2 at various pressures with evaluations of the diffusion correction have been made. It was observed that between atmospheric pressure and pressures where streamers cease, >200 mm, the value of K changes by factors of 2, 15, and 25 in dry air, room air, and H_2. The effect also appears if consistent sparking potential data are used. Errors due to method of calculation of space charge fields, while modifying, are not responsible. Though interpretation is not complete, present indications are that density of photoionization is more important than tip field in streamer propagation. Despite these observations, Meek's criterion for spark breakdown still applies in practice with $K \sim 0.1$ for air, within experimental error.

3. Electrical Breakdown in Vacuum Between Electrodes of Large Area. HOWARD S. SEIFERT, *Westinghouse Research Laboratories.*—Studies of vacuum sparks have been made heretofore with small electrodes. An increase in electrode area increases the probability of breakdown and permits examination of its statistical distribution. Concentric steel cylinders with an area of about 500 cm^2 and a spacing of 7 mm were mounted in a Pyrex envelope which was evacuated to pressures between 10^{-5} and 10^{-6} mm of Hg. Voltages to about 100 kv were applied in an effort to determine frequency of breakdown as a function of applied voltage. Voltage at which breakdown occurred depended in a complex manner upon the following factors: (1) number of previous breakdowns, (2) energy dissipated per breakdown, (3) electrode smoothness, cleanliness, and outgassing, (4) geometrical disposition of insulation with respect to high field stress, and surface condition of insulation, (5) geometry and polarity of electrodes, with special reference to bombardment of insulators by electrons, (6) gas pressure and rate of pumping. Irregular background currents of the order of 0.1 ma were observed at voltages above 60 kv, usually accompanied by fluorescence on the quartz insulating supports. It is believed that removal of all insulation from regions of strong electric field should increase the voltage limits attainable before breakdown. Experiments are under way to test this assumption.

4. Determination of Toluene by Ultraviolet Absorption Spectrophotometry. L. R. ZUMWALT, R. R. BRATTAIN, AND O. BEECK, *Shell Development Company, Emeryville, California.*—Hydrocarbon mixtures of narrow boiling range are analyzed for toluene by ultraviolet absorption spectrophotometry. Analytical samples are suitably diluted with *n*-heptane and the optical density of the solution at the toluene absorption band (268.3 mμ) is measured with a Beckman photoelectric spectrophotometer.[1] The measurement allows the determination of the toluene content of a sample to be made with an accuracy of about one percent. Conjugated diolefins which often are present in the hydrocarbon mixtures absorb strongly in this region. Therefore, a treatment of the diluted sample with aqueous alkaline potassium permanganate has been devised to remove diolefins in order to eliminate interference with the analysis. If the hydrocarbon mixtures contain olefins or if the toluene content is very low, the spectrophotometric method is found to be superior to all other known physical or chemical methods for the determination of toluene.

[1] H. H. Cary and A. O. Beckman, J. Opt. Soc. Am. 31, 682 (1941).

5. A New Band in the Infra-Red Absorption Spectrum of Ethylene. R. S. RASMUSSEN, *Shell Development Company, Emeryville, California. (Introduced by O. Beeck.)*—Several absorption maxima not previously reported were found in the infra-red absorption spectrum of ethylene in the region 12.5 to 14.5μ. The spacing is correct for maxima of an ethylene perpendicular type band, and all other indications point to the band not being due to impurity. The band is

weak, requiring a fairly high pressure to bring it out. Only ^{P}Q maxima were observed, since the ^{R}Q side and the center are overlain by the strong 950 cm^{-1} band. There is no ^{Q}Q branch, indicating that the band is of the B_{1u} type.[1] From the intensity distribution the origin is at 800 ± 5 cm^{-1}. The band cannot be interpreted as a difference band between any known frequencies. Assuming it to be the fundamental ν_9^2 places ν_{10} at *circa* 1247 cm^{-1}, from the combination band at 2047 cm^{-1}. These values for ν_9 and ν_{10} explain the observed combinations in C_2H_4 and C_2D_4 in a more satisfactory way than previous assignments.[2] To fit the observed C_p data,[1] the torsional frequency must have a value of about 950 cm^{-1}.

[1] E. J. Burcik, E. H. Eyster, and D. M. Yost, J. Chem. Phys. **9**, 118 (1941).
[2] W. S. Gallaway and E. F. Barker, J. Chem. Phys. **10**, 88 (1942).

6. Possible Assignment of the Long-Lived Yttrium. A. C. HELMHOLZ, *Radiation Laboratory, University of California.*—Dubridge and Marshall[1] tentatively assigned the 100-day yttrium to Y^{86}. Because of the large yield of this radioactive isotope from Sr+16-Mev deuterons,[2] it is suggested that Y^{88}, formed from Sr^{88} $(d, 2n)$ rather than Y^{86} formed from the eight times less abundant Sr^{86} is responsible. To test this hypothesis Y was bombarded with fast neutrons for four months. The sample then showed an activity of half-life approximately 100 days and a γ-ray absorption curve similar to that from the long-lived yttrium. The reaction would be Y^{89} $(n, 2n)$ Y^{88}. Y^{86} could be formed only from Y $(n, 4n)$. The weakness of the activity and the possibility of other rare earth contaminations, however, make the assignment uncertain. If it is correct, the long-life yttrium would be an isomer of the 2-hr. Y^{88} and at least 0.5 Mev higher in energy. A measurement of the half-life on a sample from deuteron bombardment gave 87 ± 6 days.

[1] L. A. Dubridge and J. Marshall, Phys. Rev. **58**, 7 (1940).
[2] A. C. Helmholz, C. Pecher, and P. R. Stout, Phys. Rev. **59**, 902 (1941).

7. A Cloud-Chamber Study of Heavy Particles Accelerated in the Cyclotron. RICHARD CONDIT, *Radiation Laboratory, University of California. (Introduced by E. O. Lawrence.)*—It has been found possible to produce $^{12}C^{6+}$ of energy 85 Mev and $^{16}O^{8+}$ of energy 113 Mev with the 60″ Berkeley cyclotron. Very small beams of these high speed particles were led from the cyclotron through a thin window into a Wilson cloud chamber of conventional design. Range-velocity measurements have been made for carbon at three new points, extending the known relation from a range of 0.8 cm normal air to a range of 20 cm. Two new points for oxygen have also been obtained, and the range-velocity relation extended from 5 mm to 18 mm normal air. Pictures have been obtained of the carbon and oxygen beam penetrating Cellophane and gold targets in the cloud chamber. Typical examples have thus been obtained of the scattering and straggling of these heavy particles. Many interesting chance collisions of the accelerated particles with gas atoms and with target atoms have been photographed. Some insights into the cyclotron appeared in the course of the research. A variation of heavy particle range with dee voltage was observed. Harmonic acceleration, the simultaneous appearance of accelerated ions with $e/m=\frac{1}{2}$, $\frac{1}{6}$, $\frac{1}{16}$, etc., have been demonstrated.

8. Determination of h/e by Means of the Short Wave Length Limit of the Continuous X-Ray Spectrum at 20 kv. W. K. H. PANOFSKY, J. W. M. DUMOND, AND A. E. S. GREEN, *California Institute of Technology.*—A final value of $1.3786\cdot10^{-17}$ erg sec./e.s.u. is obtained for the value of h/e by the method of isochromats as applied to the continuous x-ray spectrum. The accuracy of the experiment is materially improved by: (1) large primary x-ray intensity; (2) the use of a high resolving power 2-crystal spectrometer in conjunction with a set of balanced filters; (3) improved accuracy in voltage measurement and voltmeter standardization; (4) cleaning of the x-ray tube target in vacuum. The result is shown to be in fair, though not complete, agreement with other determinations of functions of the atomic constants. The probable error of the result is estimated as 1.6 parts in 10^4.

9. The Properties of Certain Crystals and the Value of the Avogadro Number N_0. R. T. BIRGE, *University of California.*—The value adopted for N_0 is normally one based solely on the properties of calcite—its density ρ, molecular weight M, structure constant ϕ, and lattice constant d. (The value of d is obtained from ruled grating wavelengths of x-rays, and corresponding Bragg reflection angles.) In the case of any other crystal, it is customary to use an assumed value of N_0, in order to evaluate ρ, *or* d, *or* M for the crystal. But recent accurate measurements by Johnston and Hutchison of the density of LiF and NaCl, and by Bearden of the density of diamond, make possible new precision determinations of N_0 from the properties of these three crystals. A detailed study has been made of the experimental values of ρ, d, and M for calcite, rocksalt, diamond, and LiF. The *best* crystals of these substances show little variation in either d or ρ, and the resulting values of N_0 form the consistent set—6.02276 ($CaCO_3$), 6.02392 (NaCl), 6.02323 (LiF), and 6.02335 (C), all $\times10^{23}$. The unweighted average, 6.02331, is only nine parts in 10^5 above the calcite value, and the results, taken collectively, furnish strong evidence that selected specimens of these four types of crystals may be considered geometrically perfect to at least one part in 10^4.

10. Preparation of Ross Filters. PAUL KIRKPATRICK, *Stanford University.*—Ross filters for x-ray monochromatization have usually consisted of metal sheets. For some frequency regions no metals exist. Often rolling to the required thinness is impracticable. For intensity measurements on nickel lines, copper, nickel, cobalt, iron, and manganese filters were required. Nickel was rolled to 0.0090 cm and a copper filter balanced to it by electroplating. Manganese was condensed on aluminum leaf in vacuum, and cobalt and iron were brought to balance with it by electroplating on aluminum from ferrous and cobaltous ammonium sulfate solutions. In another case a tantalum filter was brought accurately to balance against tungsten by grinding. For the highest frequencies aqueous solutions of thorium and uranyl nitrates in special cells have been

used. Elements available in fine powders but not in thin sheets have been made into filters by kneading the powder uniformly into warm paraffin wax of high melting point and pressing the mixture between spaced glass plates. The balance error resulting from dissimilarity of K jumps may be corrected by perforation of one filter or by reduction of the effective area of one. Thoeretically two filters may be brought to balance at any number of wave-lengths by giving one the proper thickness distribution.

11. Absolute K-Ionization Cross Section of the Nickel Atom under Electron Bombardment. A. E. SMICK, *Stanford University.* (*Introduced by P. Kirkpatrick.*)—Nickel targets about 5×10^{-6} cm in thickness, prepared by evaporation in vacuum and condensation upon thin cellulose acetate films, were bombarded with 70-kv electrons. The frequency of K-ionization was calculated from the observed intensity of emitted $K\alpha$ radiation. In the measurement of this radiation the lines were isolated by Ross filters of copper and nickel, the continuous background correction being evaluated by the use of filters of cobalt, iron, and manganese. (See Abstract No. 10.) A large standard ionization chamber connected to a calibrated electrometer received the radiation. The effects of absorption of the K radiation in the target, the various windows, the atmospheric air, and the gas (air) in the ionization chamber were duly considered and evaluated. Further corrections were applied for (a) electron retardation in the target, (b) single and multiple scattering of electrons within the target, (c) rediffusion by the cellulose backing and adjacent metals, (d) excitation of fluorescence radiation in the target, (e) scattering and fluorescence in the ion chamber, (f) ion current saturation deficiency. Results from different targets agreed closely and yielded as the most probable cross section 3.49×10^{-22} cm^2. Existing theories are not sufficiently precise for useful comparison, but Bethe's order-of-magnitude theory is not inconsistent with this result.

12. Energy Expended in Ionizing Argon by X-Rays. DAVID B. NICODEMUS, *Stanford University.* (*Introduced by P. Kirkpatrick.*)—A new method suggested by P. Kirkpatrick for making absolute intensity measurements of monochromatic x-rays has been used to determine the average energy expended in producing a pair of ions in a gas. This quantity ϵ is obtained by dividing the energy flux in a beam of x-rays by the rate at which it forms ions. X-rays are monochromatized by a calcite crystal and pass through a cloud chamber which produces photoelectron tracks that are recorded photographically. Since each track represents the true absorption of one quantum, the energy flux in the x-ray beam can be expressed as $Nhc/t\lambda f$ where N is the average number of tracks produced for an exposure time t, λ is the wave-length of the x-rays, and f is the fraction of the beam photoelectrically absorbed in the cloud chamber. The cloud chamber is replaced by a standard ionization chamber connected to a calibrated Compton electrometer that measures the rate at which ions are produced by the same x-ray beam. For argon at wave-lengths of 0.709A and 1.54A the measured values of ϵ are identical to within experimental error and give $\epsilon=27.4$ electron volts per ion pair.

SATURDAY AFTERNOON AT 1:30 O'CLOCK

Room 212

Paper No. 23 will be read by title.

13. The Effect of Temperature on the Production of the Afterglow of Active Nitrogen. DAVID E. DEBEAU, *University of California.* (*Introduced by Leonard B. Loeb.*)—The effect of liquid air temperature on active nitrogen has been studied. An electrodeless discharge in N_2 at a pressure of 0.5 mm of Hg gives rise to the afterglow and nearly doubles the pressure, with but a slight increase in temperature of the glass walls. Application of liquid air to less than one percent of the area of the system reduces the pressure to its original value. The afterglow is first intensified at the cold surface, then disappears, reappearing first near the cold surface after the liquid air evaporates. The pressure changes are too great to be explained by temperature changes alone, but can be attributed to the nearly complete dissociation of the N_2 in the discharge. This conclusion also follows from the results on the energy of active N_2 recently published by Rayleigh. J. J. Thomson believed that these intensity changes proved that liquid air condensed an active component of the afterglow. However, if it is assumed that the active N_2 precursor, molecular nitrogen in the B state, is one of the products of the recombination of nitrogen atoms, the observed intensity effects can be explained by the changes in the rates of the reaction involved.

14. The Orientation of Ellipsoidal Spores while Falling in Air. C. E. YARWOOD AND W. E. HAZEN, *University of California.* (*Introduced by R. B. Brode.*)—The spores of the powdery mildew *Erysiphe graminis D. C.* are one-celled, smooth-surfaced prolate ellipsoids (13×32 microns) with a large central nucleus and have a terminal velocity of 1.2 cm per second in air. When caught on glass slides after falling through air confined in a large can or a glass tube, many of the spores are found standing on end. Spores which had fallen at least 50 cm in a 7-mm glass tube were observed and photographed with a horizontal microscope ($100\times$ magnification) and 45-degree illumination from a commercial

adaption of the Edgerton flash apparatus. Six-hundred spores were observed visually and sixty-five photographically. About one-half were oriented vertically and the other half horizontally. Hydrodynamic theory gives $3mv^2 \sin 2\theta$ for the restoring torque tending to orient the axis of the spore perpendicular to the direction of motion in the case of non-viscous motion. About 0.1 sec. after starting from rest this torque (for $\theta=45°$) is so small that a displacement of the center of gravity by one percent of the spore length would orient half the spores vertically if they were randomly oriented at that time. When the air is undisturbed the spores would continue indefinitely with horizontal or vertical orientation.

15. Radioactive Sulfur from Neutron Activation of Chlorine Isotopes. M. D. KAMEN, *Radiation Laboratory, University of California.*—Samples of silver chloride, identical except for relative abundance of the two chlorine isotopes, were exposed to neutrons from the 60-inch Berkeley cyclotron. Due to the low weight (~10 mg) of the samples, a bombardment of four months was needed to obtain sufficiently active samples of the long-lived sulfur produced by the (n, p) reaction on chlorine.[1] Carrier sulfur in various valence forms was added and the samples assayed quantitatively by identical chemical procedures. From the relative activities obtained in this fashion, it was found that the amount of active sulfur produced was proportional to the Cl^{35} and not Cl^{37} present. Hence the assignment of the 88-day activity of sulfur is unambiguously fixed as S^{35} in agreement with that previously found by cross section arguments.[2] A detailed report will be published later.

[1] E. B. Anderson, Zeits. f. physik. Chemie **B32**, 237 (1936).
[2] M. D. Kamen, Phys. Rev. **60**, 537 (1941).

16. Neutron Polarization and Ferromagnetic Saturation. F. BLOCH, M. HAMERMESH, AND H. STAUB, *Stanford University.*—Measurements have been made to establish a quantitative connection between the transmission of magnetized iron for thermal neutrons and its magnetization. The change of transmission was obtained by observing the intensity of a well-collimated beam of thermal neutrons from the cyclotron, having passed through a plate of hot-rolled steel which in alternate runs was magnetized and demagnetized. The small deviations of the magnetization from its saturation value were then measured by the usual isthmus method, determining the change of B-H for values of H between about 500 and 4000 gauss. Two sets of data were taken with a total thickness of iron of 1.91 and 3.82 cm, respectively. The results strongly support the depolarization theory of Halpern and Holstein. We have verified over a fairly wide range the following dependence of the increase of transmission E upon the thickness d of the iron and the percentage deviation ϵ from saturation $E \sim d^2 f(\epsilon d)$. The theoretical form of the function f fits our data within the statistical error. By extrapolation we obtain for the increase of transmission through one cm iron on magnetizing it to complete saturation, 1.1 ± 0.2 percent.

17. A Study of Velocity-Selected Neutrons. E. M. FRYER, *Stanford University.* (*Introduced by F. Bloch.*)—The measurements have been made by means of a neutron-velocity selector similar to that of Baker and Bacher[1] and originally suggested by Alvarez.[2] The method consists in modulating the cyclotron arc with short pulses and applying similar short pulses displaced in phase to a discriminating stage in the amplifier of the counting circuit. A 2½-Mev deuteron beam and a beryllium target are used to obtain the neutrons, which are slowed to thermal velocities by paraffin. A collimated beam of thermal neutrons 2½″ in diameter and 10′ long is used. Neutrons with energies corresponding to a temperature range of 50°K to 400°K have been studied. Absorption measurements have been made with an absorption cell 20 cm long filled with BF_3 under two atmospheres pressure and the $1/v$ law for the cross section of boron verified within five percent. A distribution curve of the thermal neutrons shows a maximum at an energy corresponding to 300°K, and a half-width of roughly 200°K.

[1] C. P. Baker and R. F. Bacher, Phys. Rev. **59**, 332 (1941).
[2] L. W. Alvarez, Phys. Rev. **54**, 609 (1938).

18. A Method of Cooling Hydrogen Discharge Tubes.* CHAO-WANG HSUEH, *California Institute of Technology.* (*Introduced by W. V. Houston.*)—Most workers on the fine structure of Balmer lines have used the Wood's discharge tube and cooled it in liquid air at ordinary atmospheric pressure. Spedding, Shane, and Grace tried to cool their tube with liquid hydrogen, which proved to be unsatisfactory. To reduce the heat generated in the discharge, an electrodeless tube excited by a short-wave (68–81 meters) oscillator has been used in our Laboratory. We have tried a great number of experiments to cool our hydrogen discharge tube by means of liquid air evaporated rapidly with fast vacuum pumps. The main difficulties encountered were the leakage and the heat insulation of the system. The temperatures of the liquid air were measured with a copper-constantan thermocouple, which was calibrated at the boiling points of liquid hydrogen, nitrogen, and oxygen, the sublimation point of carbon dioxide, and the freezing points of mercury and of other organic compounds. The usual procedure is to pump the liquid air until the lowest temperature is reached. Then the oscillator is started to excite the discharge tube, while the pumping is going on. In one of our measurements, the lowest temperature attained was 55.6°K and the temperature rose slowly to 55.9°K after the discharge tube was run for 45 minutes and longer.

* Aided by a grant from the Sigma Xi Alumni Research Fund.

19. On the Lack of Saturation of Exchange Tensor Froces. G. M. VOLKOFF, *University of British Columbia.*—Nuclear models based on *non-exchange* interactions between elementary particles lead to excessive nuclear binding energies; consequently *spherically symmetrical exchange* forces were originally introduced to account for the observed saturation. Recent suggestions of additional

tensor forces find support in the discovery of the deuteron quadrupole moment, and in the results of various field theories of nuclear forces. The contribution to the nuclear binding energy made by these tensor forces was estimated by the Hartree method. If the tensor term, whether of the ordinary or of the exchange type, is assumed to be the dominant one in the interaction between a pair of nuclear particles, it will not lead to saturation, but will permit the existence of nuclei with excessive values of binding energy, spin, and isotopic number. A sufficiently strong spherically symmetrical exchange term in the interaction seems to be required to counteract this effect of the tensor forces. The feature of exchange tensor forces responsible for their lack of saturation is that a reversal of sign produced by the exchange operator may be compensated by a change in the distribution of the particles composing the nucleus from prolate to oblate.

20. Assay of Organic Molecules in Tissue from Absorption Spectra Using a Baly Tube and Densitometer. LOUIS A. STRAIT, *University of California.*—Ultraviolet spectrophotometers measure extinction coefficient or concentration of a solution within one percent. However, in analytical practice the unknown is rarely in a pure solution, being a product of preliminary extraction from a complex matrix. The unavoidable errors of extraction procedures may be tenfold the photometric error. A method which needs only a Baly tube, densitometer, and constant light source has been found convenient and sufficiently accurate. Cocaine assay from brain tissue and body fluids and assay of an estrogen from breast, tumor, and other tissues have been made. The extracted cocaine or estrogen in a quartz Baly tube was spectrographed in absorption with light from a hydrogen discharge tube. A standard solution of the cocaine or estrogen of appropriate concentration was photographed through a series of path lengths which would "map out" the absorption band over a range of densities. Transparencies of the unknown and standard concentrations were measured at wave-length of maximum absorption. From a graph (preferably log-log) of path length of known concentration *versus* transparency (Fig. 1) the corresponding path length of the unknown and, by application of Beer's law, its concentration may be evaluated. Significant data describing the permeability property of the blood-brain barrier are evidenced in Fig. 2, the relationship of estrogen to tumor formation in Fig. 3.

21. On Fitting Data with Polynomial Functions by the Method of Least Squares. J. WEINBERG, *University of California.* (*Introduced by R. T. Birge.*)—A general formula is derived for the coefficients of an nth degree polynomial $p_n(x)$ fitted by the method of least squares to data $y(x)$ for $x=0, 1, \cdots (N-1)$, where one uses the factorial form

$$p_n(x)=\sum_{m=0}^{n}(-)^m\binom{2m}{m}a_{mn}\binom{x+m}{m}\Big/\binom{N+m}{m}.$$

In particular,

$$a_{nn}=(2n+1/N)\binom{N-1}{n}^{-1}\sum_{x=0}^{N-1}y(x)$$

$$\times\sum_{k=0}^{n}(-)^k\binom{n+k}{k}\binom{N-k-1}{n-k}\binom{x}{k},$$

which confirms the expression obtained empirically by Birge and Shea[1] for the coefficient of x^n. For $m<n$, the general formula leads to

$$a_{mn}=\sum_{k=m}^{n}\binom{m+k}{2k}a_{kk}.$$

This corresponds to the rapid and direct mode of solution found by Birge and Shea, who, however, give explicit formulas only for $n\leqslant 5$.

[1] R. T. Birge and J. D. Shea, University of California Publication in Mathematics 2, No. 5 (1927).

22. Theory of the Spread of Cosmic-Ray Showers. JANE ROBERG, *Duke University.* (*Introduced by L. W. Nordheim.*)—In continuation of the work reported at the Baltimore meeting the following results have been obtained. The mean square angular and lateral spreads of both shower electrons and photons above the critical energy have been obtained as function of energy for all substances. They have also been computed for air for the low energy range down to four Mev. The root mean square lateral deviation for electrons of all energies above four Mev is found to be 63 meters in normal air. In these calculations close approximations to the true probabilities for radiative effects have been used, and both pair production and Compton effects have been taken into account at low energies.

23. Multiple Scattering of Fast Electrons. C. W. SHEPPARD, *California Institute of Technology.*—The multiple scattering of B^{12} electrons has been studied in carbon and lead scatterers using G.M. coincidence counters. Comparison was made of scattering in two laminae of equal NTZ^2. The ratio of the arithmetical mean angles of scattering was nearly the same experimentally as given by the theoretical expression of Williams. The difference in transmission of carbon and lead scatterers was compensated for by placing the carbon scatterer between the counters when the lead was scattering, and vice versa. The mean error in the measured scattering ratio was estimated to be ten percent.

24. Measurement of the Ionization of Fast Mesotrons with a High Pressure Ionization Chamber. W. C. DUNLAP, *University of California.*—An ionization chamber and a pulse amplifier have been used to measure the ionization in argon of mesotrons capable of penetrating 8 cm of lead. A pair of counters was mounted above and below the chamber so that a mesotron tripping the counter passed between two rectangular plates, one of which was the

collector. A block of lead 7.5 cm thick was also inserted between the counters. Results were obtained by having the counters trip the sweep of an oscillograph connected to the output of the amplifier, so that the pulse size could be observed visually or from a photographic film. The amplifier was made after the design of Waddell, and was calibrated by means of an audiofrequency generator and with polonium α-particles. The apparatus was sensitive enough to detect cosmic-ray particles at atmospheric pressure. Measurements were made at pressures from 10 to 70 atmospheres. Calculations for a run at 25 atmospheres show an average ionization of 46 ions/cm at one atmosphere assuming all pulses due to single particles. These observations are being continued and extended.

SUPPLEMENTARY PROGRAMME

25. Reduction of the Problem of Arbitrary Spin to That of Spin 1/2. F. BLOCH, *Stanford University.*—It has been shown by Majorana[1] and is implied in the usual group theoretical methods that the wave mechanics of a system with arbitrary angular momentum j (in units $h/2\pi$) can be reduced to that of a system with $j=\frac{1}{2}$. These rather abstract methods can be seen to be equivalent to the well-known vector model in which an angular momentum j can be represented as the sum of $2j$ angular momenta of value $\frac{1}{2}$. The mathematical expression of this fact is obtained by the symmetrized product of $2j$ arbitrary wave functions, each representing a system with spin $\frac{1}{2}$ and by showing that this yields the description of the most general state of a system with spin j. The transformation which a state of a system with arbitrary spin j undergoes under given physical conditions can be derived in an elementary way from that which a system with spin $\frac{1}{2}$ undergoes under the same conditions.

[1] E. Majorana, Nuovo Cimento **9**, 43 (1932).

26. A Simple Excitation Source for Quantitative Spectrochemical Analysis—Analysis of Pb in Tissues. LOUIS A. STRAIT, *University of California.*—A source of excitation suitable for quantitative spectrochemical analysis must vaporize the sample in a representative manner and must readily excite the components of the sample to give off characteristic radiations reproducibly. The reproducibility of excitation conditions in the condensed spark source previously described here[1] was limited by the degree of uniformity of the deposition of the sample on a lower moveable copper cylindrical electrode. The following modifications have simplified this source and extended its usefulness: I. Preparation of the sample: The sample is deposited on a thin paper (e.g., lens paper) and after drying the paper is wrapped around the lower cylindrical electrode. II. Excitation of the sample: The contents of the paper are vaporized and excited by feeding the paper covered cylinder into the electrical discharge between the upper point electrode and the cylinder. The discharge is uncondensed and is excited by the secondary of a 3-kva, 5000-volt transformer. The secondary current is 150 milliamperes. The source has been applied to the analysis for Pb of ashed samples of tissues and organs of mice. The customary procedure of analysis was followed using internal standard (Cd in this case) and "working" curves.

[1] Louis A. Strait, Phys. Rev. **56**, 855 (1939).

27. Application of the Edgerton Lamp to Droplet Counting. W. M. POWELL, *Kenyon College.**—A Wilson cloud chamber fourteen inches deep and eight inches in diameter is illuminated by two beams of light which enter the chamber at the base of the cylinder and cross in the middle. The chamber is surrounded by Helmholz coils which give a magnetic field of 2500 oersteds. The light source consists of two rectangular tubes ten cm long and 3.2 by 0.8 cm in cross section. The electrodes are 40-mil tungsten T's 8.2 cm apart. Two of these tubes are connected in series with a 150-μf condenser which is charged to 2000 volts. They stand behind condenser lenses 4.5 inches in diameter and 3 inches in focal length. The tubes are filled with a very small amount of hydrogen and 3.5 cm of argon. Two pieces of chromium plated brass are pressed against the back of the two tubes. They perform the double service of mirrors and tickler electrodes. Droplets were photographed 0.15 sec. or less after expansion of the chamber with an F number of 9 and appeared to be overexposed by about four times. The illumination appears to be quite uniform.

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